

BROMINE COMPOUNDS (INORGANIC)

CAS Registry Numbers: Bromine: 7726-95-6 Br
Potassium Bromate: 7758-01-2 KBrO₃

Molecular Formulas: Br₂
BrO₃K

Bromine is a dark reddish-brown, volatile, diatomic liquid, and can also occur as rhombic crystals. It has a suffocating odor, is corrosive, and vaporizes rapidly at room temperature. Bromine is a strong oxidant especially in the presence of water. It is freely soluble in water, alcohol, ether, chloroform, carbon disulfide, carbon tetrachloride, and concentrated hydrochloric acid (HSDB, 1993; Merck, 1989; Sax, 1989).

The most common inorganic bromides are sodium, potassium, ammonium, and calcium bromides. Potassium bromate is a common inorganic bromide and for the report, was used as an example for the group of bromine compounds. Potassium bromate appears as white or colorless, trigonal crystals or crystalline powder (HSDB, 1993). It decomposes at 370 °C releasing oxygen and is a powerful oxidizer. Potassium bromate is soluble in water and almost insoluble in alcohol (Merck, 1989). Methyl and ethyl bromides are among the most common organic bromides.

Physical Properties of Bromine and Potassium Bromate

Synonyms for bromine: bromine solution

Synonyms for potassium bromate: bromic acid, potassium salt

| | <u>Bromine</u> | <u>Potassium Bromate</u> |
|---------------------------|--------------------------------|--------------------------------|
| Molecular Weight: | 159.82 | 167.01 |
| Valences: | 1 to 7 | |
| Boiling Point: | 59.47 °C | |
| Melting Point: | -7.25 °C | 350 °C |
| Vapor Density: | 5.5 at 15 °C (air = 1) | |
| Density/Specific Gravity: | 3.12 at 20/4 °C (water = 1) | 3.27 at 17.5 °C (water = 1) |
| Vapor Pressure: | 175 mm Hg at 21 °C | |

(Merck, 1989; Sax, 1989)

SOURCES AND EMISSIONS

Toxic Air Contaminant Identification
List Summaries - ARB/SSD/SES

September 1997

A. Sources

Bromine is used as an analytical reagent and chemical intermediate for bromine compounds, in non-drinking water disinfection, bleaching fibers and silk, the manufacture of medicinal bromine compounds and dyestuffs, as a fire retardant for plastics, in photography, for shrink-proofing wool, and for gold extraction (HSDB, 1993; Merck, 1989). The primary stationary sources that have reported emissions of bromine in California are electrical services, national security, and steam and air conditioning supply services (ARB, 1997b).

Potassium bromate is manufactured in California (HSDB, 1993). It is a bread and flour-improving agent used as a dough conditioner, and is also used as a food additive, analytical reagent, and in permanent wave conditioners (Merck, 1989). Bromine and compounds have also been identified but not quantified in motor vehicle exhaust by the Air Resources Board (ARB) (ARB, 1991e).

B. Emissions

The total emissions of bromine from stationary sources in California are estimated to be at least 31,000 pounds per year, based on data reported under the Air Toxics "Hot Spots" Program (AB 2588) (ARB, 1997b).

C. Natural Occurrence

Bromine occurs in igneous rock at 1.6×10^{-4} percent by weight and in seawater at 65 parts per million. Because of its high reactivity, bromine does not appear in its pure form in nature. It is found as a normal secondary component of chlorine in minerals and biological systems (HSDB, 1993; Merck, 1989).

AMBIENT CONCENTRATIONS

Bromine and its species are routinely monitored by the statewide ARB air toxics network. The network's mean concentration of bromine and its species from January 1996 through December 1996 is estimated to be 8.4 nanograms per cubic meter (ng/m^3) (ARB, 1997c).

INDOOR SOURCES AND CONCENTRATIONS

In a field study conducted in southern California, investigators collected particles (PM_{10}) inside 178 homes and analyzed the particle samples for selected elements, including bromine. Two consecutive 12-hour samples were collected inside and immediately outside each home. Average indoor bromine concentrations were $13 \text{ ng}/\text{m}^3$ in the daytime and $11 \text{ ng}/\text{m}^3$ in the nighttime. Corresponding average outdoor concentrations were similar; $10 \text{ ng}/\text{m}^3$ in the daytime and $13 \text{ ng}/\text{m}^3$ in the nighttime. Indoor concentrations ranged from approximately

2.8 ng/m³ to 40 ng/m³ (Pellizzari et al., 1992).

ATMOSPHERIC PERSISTENCE

Bromine (Br₂) will photolyze rapidly (about 1 minute) to form Br atoms, which then react with ozone to ultimately form aerosol and/or particulate bromine (Fan and Jacob, 1992). No information on the atmospheric half-life and lifetime of bromine was found in the readily-available literature.

Potassium bromide will exist in the particle phase and be subject to wet and dry deposition. The average half-life for particles and particle-associated chemicals in the troposphere is estimated to be about 3.5 to 10 days (Balkanski et al., 1993).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program. Of the risk assessments reviewed as of December 1996, bromine and bromine compounds were not listed in any of the risk assessments (OEHHA, 1996a,b).

HEALTH EFFECTS

Probable routes of human exposure to bromine and bromine compounds (bromine, potassium bromate, hydrogen bromide, bromine pentafluoride) are inhalation, ingestion, and dermal contact.

Non-Cancer: Exposure to bromine gas by inhalation immediately produces irritation of the respiratory system, tearing, coughing, headache, and dizziness (Sittig, 1991). Subsequent effects may include lung inflammation, abdominal pain, diarrhea, and skin eruptions resembling measles. High level exposure can lead to bronchitis, light sensitivity, and spasms of the eyelid and throat accompanied by swelling. Chronic exposure can lead to headache, irritability, anorexia, joint pain, cardiovascular disorders, gastrointestinal disorders, and thyroid enlargement and dysfunction (HSDB, 1995).

Exposure to bromine pentafluoride or bromine trifluoride may cause severe irritation of the eyes leading to clouding and necrosis of the cornea, skin irritation, difficulty breathing, cough, and pulmonary edema (Sittig, 1991). Acute exposure of experimental animals to bromine pentafluoride has been shown to cause tearing, salivation, and eyelid swelling. Chronic exposure has produced kidney and liver damage (HSDB, 1995).

Hydrogen bromide exposure results in irritation of the eyes, upper respiratory tract, and skin because of its acidity (HSDB, 1995). Higher levels of exposure can cause burns and necrosis of the skin.

Inhaled mists or dusts of potassium bromate can cause irritation of the eyes, nose, throat, bronchial tubes, and skin (Sittig, 1991). Skin irritation may progress to burns. Potassium bromate is absorbed through the skin. Systemic exposure has been shown to result in convulsions, gastrointestinal effects (nausea, vomiting, diarrhea, epigastric pain), and acute renal failure (HSDB, 1995).

Chronic non-cancer Reference Exposure Levels (RELs) are listed for three compounds of bromine in the California Air Pollution Control Officers Association Air Toxics “Hot Spots” Program, Revised 1992 Risk Assessment Guidelines. These RELs are: 1.7 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) based upon respiratory effects for bromine; 24 $\mu\text{g}/\text{m}^3$ based upon respiratory effects for hydrogen bromide; and 1.7 $\mu\text{g}/\text{m}^3$ based upon respiratory, gastrointestinal, and kidney effects for bromine pentafluoride (CAPCOA, 1993). Bromoxynil, a pesticide containing bromine, is listed by the State of California under Proposition 65 as a developmental toxicant (CCR, 1996).

Cancer: Experiments in animals have shown that potassium bromate given in drinking water causes kidney tumors and mesotheliomas. The carcinogenic potential of potassium bromate is under review by the United States Environmental Protection Agency (U.S. EPA, 1995a). The International Agency for Research on Cancer has classified potassium bromate in Group 2B: Possible human carcinogen, based on the absence of data in humans and sufficient evidence in experimental animals (IARC, 1987a).

The State of California has determined under Proposition 65 that potassium bromate is a carcinogen (CCR, 1996). The inhalation potency factor that has been used as a basis for regulatory action in California is 1.4×10^{-4} (microgram per cubic meter)⁻¹ (OEHHA, 1994). In other words, the potential excess cancer risk for a person exposed over a lifetime to 1 $\mu\text{g}/\text{m}^3$ of potassium bromate is estimated to be no greater than 140 in 1 million (OEHHA, 1994).